CLAIMS

What is claimed is:

1. A method for generating flow vectors based in part on the D8 method for all or part of a watershed divided into at least one predefined, rectangular major cell encompassing at least nine predefined, rectangular minor cells including a center minor cell and eight neighbor minor cells wherein the watershed includes one or more problem areas identified as depressions, flat areas or peaks each of which extends across one or more major cells and each of which requires fixing and wherein further the number, location and elevation of all minor cells are known as are the maximum depth depression to be corrected, the maximum number of downstream minor cells to check in fixing depressions and peaks, the largest depression area to fix and the largest flat area to fix, comprising:

if flow vectors for minor cells within more than one major cell are desired, designating one major cell for which to begin generating flow vectors;

creating a buffered array containing elevation and identification data for all minor cells in the designated major cell and all major cells, if any, bordering the designated major cell;

calculating flow vector values for each minor cell within the buffered array using the D8 method wherein a flow vector value of zero is assigned to any minor cell located in a problem area for which a flow vector value cannot be calculated using the D8 method;

storing the calculated flow vector values in association with the minor cell to which they relate;

checking the flow vector value of each minor cell within the designated major cell until all cells have been checked and all cells having a flow vector value of zero have been found;

assigning a problem type to each minor cell having a flow vector value of zero;

fixing first all minor cells in the designated major cell to which a depression problem type has been assigned wherein depressions are fixed independently and successively from the highest depression to the lowest depression and elevation changes are imposed on minor cells, as required;

fixing second all minor cells in the designated major cell to which a flat area problem type has been assigned wherein each flat area is fixed independently and elevation changes are imposed on minor cells, as required;

fixing third all minor cells in the designated major cell to which a peak problem type has been assigned wherein peaks are fixed independently and successively from the lowest peak to the highest peak and elevation changes are imposed on minor cells, as required;

recalculating flow vector values for each minor cell within the buffered array using the D8 method wherein a flow vector value of zero is assigned to any minor cell located in a problem area for which a flow vector cannot be calculated using the D8 method;

checking again the flow vector value of each minor cell within the designated major cell until all cells have been checked and all cells having a flow vector value of zero, if any, are found;

if any minor cells having a flow vector value of zero have been found,

fixing first all minor cells in the designated major cell to which a depression problem type has been assigned wherein depressions are fixed independently and successively from the highest depression to the lowest depression by imposing elevation changes on minor cells, as required;

fixing second all minor cells in the designated major cell to which a flat area problem type has been assigned wherein each flat area is fixed independently by imposing elevation changes on minor cells, as required;

fixing third all minor cells in the designated major cell to which a peak problem type has been assigned wherein peaks are fixed independently and successively from the lowest peak to the highest peak and elevation changes are imposed on minor cells, as required;

storing the elevation and flow vector data associated with each minor cell as changed, if necessary; and

if there are unselected major cells remaining, selecting another major cell and returning to the creating a buffered array step.

2. The method of claim 1 wherein the calculating step for each minor cell further comprises:

retrieving identification and elevation data for the minor cell;

if that minor cell is located on the edge of the buffered array, assigning a flow vector value of zero to that minor cell;

if a distinct flow direction from that minor cell to one of its eight neighboring minor cells can be ascertained, assigning a flow vector of between one and nine to the minor cell wherein each number represents a different direction; and

otherwise assigning a flow vector value of zero to the minor cell.

3. The method of claim 1 wherein the assigning step for each minor cell having a zero flow vector value further comprises:

obtaining the location and elevation of all neighbor cells of the minor cell;

if the minor cell is at the edge of the buffered array, assigning the problem type as "edge";

calculating the slope from the minor cell to each of its eight, surrounding neighbor cells in order to find a maximum slope and,

if the elevation of the minor cell is lower than each of those neighbor cells, assigning the problem type as "depression";

if the maximum slope from the center cell to one or more neighbor cells equals zero, assigning the problem type as "flat"; and

if the maximum slope from the center cell to more than one neighbor cell does not equal zero, assigning the problem type as "peak".

4. A method for generating flow vectors for all or part of a watershed divided into at least one predefined, rectangular major cell encompassing at least nine predefined, rectangular minor cells including a center minor cell and eight neighbor minor cells, wherein the watershed includes one or more problem areas identified as depressions requiring flow vector correction of minor cells therein, each of which extends across one or more major cells, wherein the number, location and elevation of all minor cells are known as are the largest depression area to be corrected, the maximum number of times the maximum depth depression may be modified in an attempt to fix any individual depression and the maximum number of downstream cells permitted to be checked to find a good outlet and wherein further a buffered array containing elevation and identification data for all minor cells in a designated major cell and in all major cells, if any, bordering the designated major cell has been established and flow vector values for all minor cells in the buffered array have been calculated to the extent possible based on the D8 method and any minor cell located in a depression has been assigned a zero flow vector value, comprising:

initializing a first variable to track the highest depression elevation found;

flagging that original minor cell in the designated major cell having a zero vector value which has the highest elevation as compared with all other minor cells having zero vector values located in the designated major cell;

retrieving location and elevation data for the flagged original minor cell and its neighbor minor cells;

setting a depth limit to a preselected amount to limit the maximum depth depression to correct;

initializing a second variable to track the number of times the maximum depth depression has been modified up to a preselected maximum number of times;

creating a depression array mirroring the buffered array for identifying those minor cells which contribute to the depression;

increasing the second variable by one;

defining the area contributing to the depression;

identifying potential outlets from the depression;

determining whether any of the potential outlets from the depression is a good outlet;

if no good outlet is found,

exiting the method if

the contributing area extends beyond the buffered array; or

the number of maximum depth modification attempts equals the preselected maximum number of times;

otherwise, incrementing the depth limit by an amount equal to one-eighth of the depth limit;

if the depth limit is greater than the combination of the elevation of the flagged original minor cell and the depth limit as originally set, exiting the method;

otherwise, returning to the creating a depression array step;

if a good outlet exists,

choosing the good outlet having the lowest elevation;

drawing a straight line from the center of the flagged original minor cell to the good outlet cell;

extending the straight line to follow a downstream path to an elevation lower than the elevation of the flagged original minor cell;

burning a cutline into the buffered array by correcting elevations in minor cells, as necessary;

recalculating flow vectors for all minor cells in the buffered array if the depression is fixed; and

until all depressions are fixed, returning to the flagging step.

5. The method of claim 4 wherein zero flow vector values may also be assigned to minor cells which are unfixable or with which no data is associated.

6. The method of claim 5 wherein the following step precedes the initializing a first variable step:

creating a Boolean array corresponding in size to the buffered array for tracking unfixable cells.

7. The method of claim 6 wherein the flagging step ignores minor cells which are either unfixable or have no data associated with them.

8. The method of claim 4 wherein the depth limit is initially set at one-half of the originally specified maximum depth depression.

9. The method of claim 4 wherein the defining step further comprises:

obtaining data identifying the location and elevation of a center minor cell;

testing each of the eight neighbor minor cells surrounding the center minor cell to determine if the elevation of any neighbor minor cell is greater than or equal to the elevation of the center minor cell;

if so, flagging the center minor cell as a contributing minor cell and redesignating that neighbor minor cell as the center minor cell if the elevation of the neighbor minor cell is less than the depth limit and the neighbor minor cell is not located at the edge of the buffered array;

returning to the obtaining data step until all neighbor minor cells of all minor cells in the buffered array have been tested or until a stack space error is encountered or the center minor cell is determined to be located at the edge of the buffered array in which case the method is exited.

10. The method of claim 9 including the following steps after the defining step:

if an error is encountered during the defining step,

exiting the method if stack space has been exceeded, the area has already been flagged as too shallow or the preselected maximum number of times to attempt fixing the depression array has been reached;

incrementing the depth limit;

if the depth limit after incrementing is not less than the original elevation,

resetting the depression array;

incrementing the second variable by one; and

returning to the defining step;

exiting the method if the depth limit after incrementing is less than the original elevation.

11. The method of claim 10 wherein in the incrementing step the depth limit is increased by one-eighth of the initial depth limit.

12. The method of claim 4, wherein the identifying potential outlets step further comprises:

obtaining data identifying the location and elevation of a contributing minor cell and of its neighbor minor cells ;

identifying which of the eight neighbor minor cells of the contributing minor cell is not part of the contributing area;

testing whether the elevation of any such neighbor minor cell is less than the elevation of the contributing minor cell;

if so, flagging such neighbor minor cell as an exterior cell;

after all neighbor minor cells have been so tested, further flagging the contributing minor cell as a potential outlet if at least one neighbor minor cell has been flagged as an exterior cell.

13. The method of claim 12, wherein the determining step is a subroutine further comprising the steps of:

obtaining data identifying the location and elevation of a contributing minor cell flagged as a potential outlet and of its neighbor minor cells;

setting a trace counter equal to zero;

incrementing the trace counter by one;

exiting the subroutine if the trace counter indicates a value greater than the maximum number of downstream cells permitted to be checked;

obtaining data for the location and elevation of the next downstream minor cell;

testing whether that downstream cell is located at the edge of the buffered array;

if so, exiting the subroutine;

if not, further testing whether the elevation of the downstream minor cell is less than the elevation of the flagged original minor cell;

if so, flagging the potential outlet as a good outlet and exiting the subroutine; and

if not, returning to the incrementing step.

14. A method for generating flow vectors for all or part of a watershed divided into at least one predefined, rectangular major cell encompassing at least nine predefined, rectangular minor cells including a center minor cell and eight neighbor minor cells, wherein the watershed includes one or more problem areas identified as peaks requiring flow vector correction of minor cells therein, each of which extends across one or more major cells, and the number, location and elevation of all minor cells are known as are the

maximum number of downstream cells to check and wherein further a buffered array containing elevation and identification data for all minor cells in a designated major cell and in all major cells, if any, bordering the designated major cell has been established and flow vector values for all minor cells in the buffered array have been calculated to the extent possible based on the D8 method and any minor cell located in a peak has been assigned a zero flow vector value, comprising:

flagging that original minor cell in the designated major cell having a zero vector value which has the lowest elevation as compared with all other minor cells having zero vector values located in the designated major cell;

retrieving location and elevation data for the flagged original minor cell and its neighbor minor cells;

finding the maximum slope existing between the flagged original minor cell and one of its neighbor minor cells using the D8 method;

identifying each neighbor minor cell where the slope between that cell and the flagged original minor cell equals the maximum slope;

marking each such neighbor minor cell as a potential path;

if there are not multiple potential paths, exiting the method;

tracing each potential path downstream from each flagged neighbor minor cell up to the specified maximum number of downstream cell iterations wherein for each iteration the maximum slope is reset to be equal to the steepest slope between a downstream cell and one of its neighbor minor cells if that slope is the steepest slope found from that downstream cell;

randomizing a best path selection, if there are no potential paths remaining or if there are multiple potential paths remaining;

designating the remaining single potential path as the best path;

lowering the elevation for the first neighboring minor cell of the flagged original minor cell along which the best path runs;

recalculating flow vectors for all minor cells in the buffered array if the peak is fixed; and

until all peaks are fixed, returning to the flagging step.

15. The method of claim 14 wherein zero flow vector values may also be assigned to minor cells which are unfixable or with which no data is associated.

16. The method of claim 15 wherein the following step precedes the initializing a variable step:

creating a Boolean array corresponding in size to the buffered array for tracking unfixable cells.

17. The method of claim 14 wherein randomizing further comprises:

identifying each potential flow path with a sequential number beginning at one;

dividing the number of remaining potential flow paths by two to obtain a quotient;

designating the sequential number of the potential flow path corresponding to the quotient as the best flow path.

18. The method of claim 14 wherein the lowering step comprises reducing the elevation by .000001 feet.

19. The method of claim 14 wherein the following further steps are included after the lowering step:

verifying that lowering of the elevation does not introduce unexpected problems or undesirable flow direction changes;

if problems or changes were introduced, returning the elevation to its original level and exiting the method.